

Laboratory Demonstration and Test of Solar Thermal Asteroid ISRU

Completed Technology Project (2015 - 2017)



Project Introduction

We will prove the key technical components of an ISRU facility that can potentially beneficiate hundreds of tonnes/yr of volatile material from small carbonaceous asteroids and process this material into H₂O, CO₂, hydrocarbons (e.g. methane) and LOX propellant. This proof of concept will allow humanity to confidently develop propellant and materials processing plants and depots at the top of the Earth's gravity well. A key motivation is to enable human missions to Mars or the Moon to launch with less propellant, water, and oxygen than currently required. Crewed exploration missions will be supplied at the depot and depart with full tanks, dramatically reducing the cost of exploration and development of the solar system and proving that humans can "live off the land" in space using asteroids as feedstocks. This concept is motivated by the need for extremely lightweight, practical, and inexpensive ISRU that once developed can be used on NEOs in the size range of ARM targets (or pieces of ARM targets) in a micro-g environment. This concept makes maximum use of thin-film capture and enclosure mechanisms (like ARM) for material processing; low-pressure thin-film inflatable solar concentrators for the lightest possible, high-quality solar thermal power; deployable thin-film sun shields for cold traps and temperature control; and material processing systems without significant electronics, robotics, complex mechanisms, or mechanical components. Our proposal will provide design concepts that show how small Diaphanous Systems can be used to capture and contain small asteroids, pyrolytically devolatilize large quantities of water and carbon dioxide, separate the extracted volatile constituents, and store them at a depot as useful resources for exploration and industry. Although some system components are currently at TRL 4 or above, the use of these components in a light-weight, practical design to extract and process volatiles from an asteroid is currently at TRL 1-2. Our focused research program will advance the concept to TRL 3. We will do this by building a sub-scale laboratory apparatus that simulates the effect of a solar thermal furnace on small, unprocessed samples of carbonaceous meteorites, then on small samples of asteroid simulants, to validate their similarity to the target meteorites, and then on larger (meter-scale) carbonaceous asteroid simulants. Our proposal will cite scientific work proving that pyrolysis can thermally devolatilize H₂O from carbonaceous meteorites at 250C and CO₂ at 600C. We will extend that work to engineering applications of how the materials are preprocessed and perform the experiments in a space-like environment in a vacuum chamber. We will show how solar thermal surface heating propagates through asteroidal material, how the porosity and friability of the asteroidal material affect the out-migration of volatiles, and the degree to which applied mechanical shock and/or other mechanical processing is needed to enhance gas transport. Our team is led by Dr. Leslie Gertsch, Deputy Director, Rock Mechanics & Explosives Research Center at Missouri University of Science and Technology in an industrial partnership with ICS Associates Inc, and its Chief Engineer, Dr. Joel Sercel who will provide systems engineering and mission perspective. Our technical advisors include Mr. Robert Mueller of KSC who will



Laboratory Demonstration and Test of Solar Thermal Asteroid ISRU

Table of Contents

Project Introduction	1
Anticipated Benefits	2
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	2
Project Website:	3
Technology Areas	3
Target Destination	3

Laboratory Demonstration and Test of Solar Thermal Asteroid ISRU



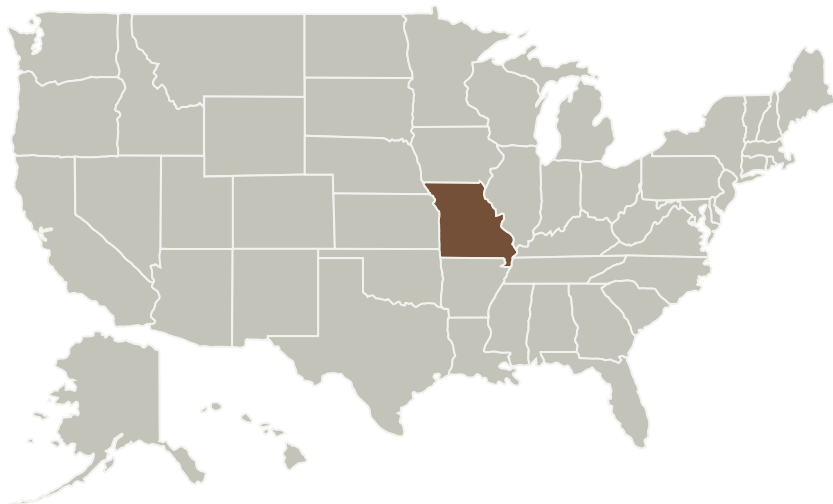
Completed Technology Project (2015 - 2017)

provide linkage to NASA programs; Prof. Robert Jedicke of the Institute for Astronomy, University of Hawaii, an expert on orbit distributions, sizes and origins of NEOs; and Dr. Alexander N. Krot, faculty researcher at the University of Hawaii and expert on meteorite mineralogy. NASA Technology Area: 7

Anticipated Benefits

Our proposal will provide design concepts that show how small Diaphanous Systems can be used to capture and contain small asteroids, pyrolytically devolatilize large quantities of water and carbon dioxide, separate the extracted volatile constituents, and store them at a depot as useful resources for exploration and industry.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Missouri University of Science and Technology	Lead Organization	Academia	Rolla, Missouri

Primary U.S. Work Locations

Missouri

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Missouri University of Science and Technology

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

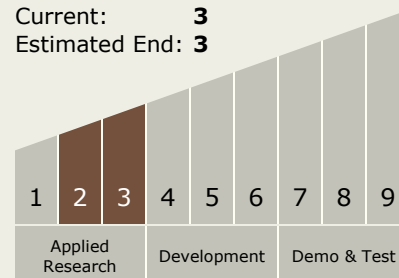
Hung D Nguyen

Principal Investigator:

Leslie Gertsch

Technology Maturity (TRL)

Start: 2
Current: 3
Estimated End: 3





Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Technology Areas

Primary:

- TX07 Exploration Destination Systems
 - └ TX07.1 In-Situ Resource Utilization
 - └ TX07.1.2 Resource Acquisition, Isolation, and Preparation

Target Destination

Others Inside the Solar System